See figure 10 and 11 for the timing of the downlink window.

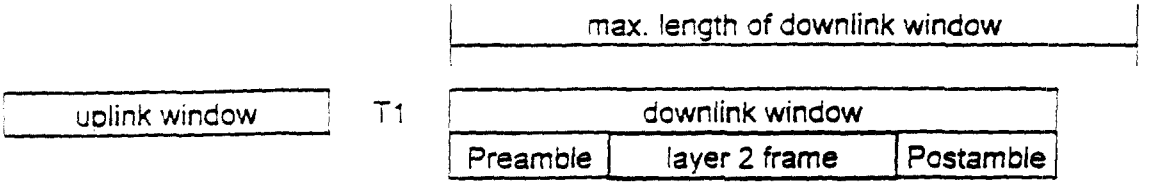


Figure 10: Timing Of Downlink Window After Uplink Window

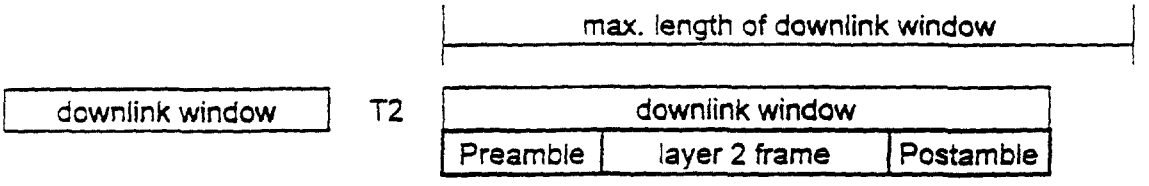


Figure 11: Timing Of Downlink Window After Downlink Window

NOTE: From N2 the maximum duration in time of the downlink window may be calculated, taking bit rate and zero bit insertion into account.

6.1.2 Uplink Windows

The *Fixed MAC* allocates one or more uplink windows immediately following a downlink frame by setting the A bit of the MAC control field of the downlink frame to 1.

There are two kinds of uplink windows, private uplink windows and public uplink windows.

A private uplink window may only be used by one mobile MAC, while public uplink windows may be used by any mobile MAC according to certain rules described in subclause 6.1.2.3.

If the link address of the allocating downlink frame is a private address, the allocated uplink window is a private uplink window. If the link address of the allocating downlink frame is a broadcast address, the allocated uplink window(s) is/are public uplink window(s).

Each allocating downlink frame may thus allocate either

a) one private uplink window or

b) one or more consecutive public uplink windows

6.1.2.1 Private Uplink Windows

A private uplink window may only be used by the mobile MAC having a private link address equal to the link address of the frame allocating the window.

The start of a private uplink window occurs T3 after the end of the downlink window containing the frame allocating the uplink window.

The end of a private uplink window occurs:

a) T4a after the start of the window, if no mobile MAC has started transmitting before that time

b) at the end of the last bit of the postamble if applicable or otherwise the last bit of the end flag of the uplink layer 2 frame transmitted

A frame transmitted in a private uplink window shall consist of not more than N3 octets.

Figure 12 shows the timing for the private uplink window.

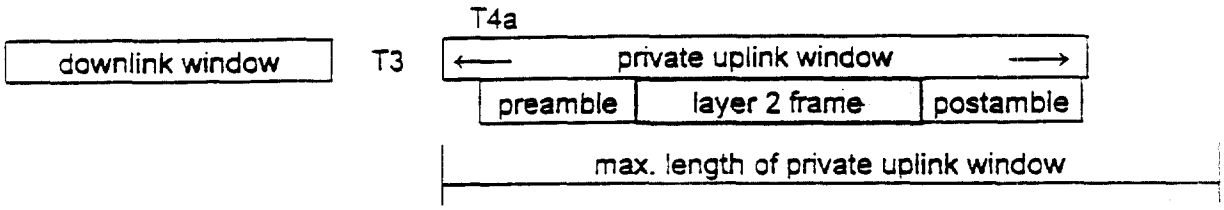


Figure 12: Private Uplink Window Timing

NOTE: From N3 the maximum length in time of the private uplink window may be calculated, taking bit rate and zero bit insertion into account.

6.1.2.2 Public Uplink Windows

Each downlink frame allocating a public uplink window can allocate one or more consecutive public uplink windows. The number of consecutive public uplink windows simultaneously allocated by one downlink frame is N5.

A public uplink window may be used by any mobile MAC according to certain rules, see subclause 6.1.2.3.

The start of a public uplink window occurs

a) T3 after the end of the downlink window containing the frame allocating the window if the public uplink window is the first window after the downlink window or

b) immediately after the end of the previous window if that window is a public uplink window

The end of a public uplink window occurs T5 after the start of that window.

The transmission of the first bit of the preamble if applicable or otherwise the first bit of the start flag of the layer 2 frame in a public uplink window shall start before T4b after the start of that window.

A frame transmitted in a public uplink downlink window shall consist of less than N4 octets.

See figure 13 for the timing of the public uplink window.

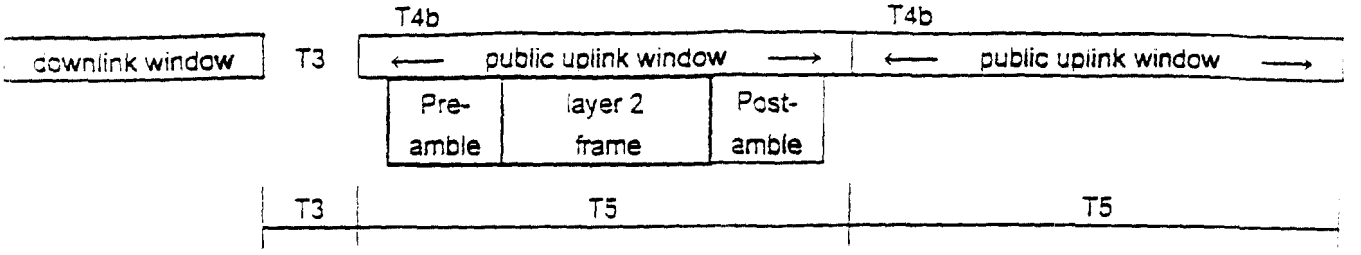


Figure 13: Public Uplink Window Timing

NOTE: N4, T4 and T5 must have reasonably corresponding values, taking bit rate and zero bit insertion into account, to provide the necessary guard time at the window end.

6.1.2.3 Public Uplink Window Selection Mechanism

The public uplink window selection mechanism is a random delay counter mechanism.

The fixed MAC may allocate one or more consecutive public uplink windows each time.

The number of simultaneously allocated consecutive public uplink windows is N5.

The first public uplink window transmission indicator V(PUB) of the mobile MAC shall be set to *0* after arriving in a communications zone (see clause 5. Address Establishment).

When the mobile MAC needs to select a public uplink window for transmission it:

- shall randomly generate an integer N7, larger than or equal to *1* or smaller than or equal to N8 (i.e. *1* <= N7 <= N8; N7 shall be uniformly distributed between *1* and N8).

- if V(PUB) equals *0* and N5 equals *1* then
  the mobile MAC shall set the public uplink window counter N6 to N7 - *1*,

  otherwise
  the mobile MAC shall set the public uplink window counter N6 to *0*.

NOTE: The first public uplink window indicator V(PUB) is set to 0 whenever the mobile MAC arrives in a new communication zone. If the number of consecutive public uplink windows N5 is 1, then if V(PUB) equals 0 the next available public uplink window is used for uplink transmission, after which V(PUB) is set to 1. This guarantees the highest performance for "single-lane" scenarios (no other vehicles in the communication zone) as well as for "multiple-lane" scenarios with a low probability that two or more vehicles are arriving in the communication zone at the same time.

Whenever a new (consecutive) Public Uplink Window is valid the mobile MAC shall increment N6 by *1*.

Whenever the counter N6 equals N7 the mobile MAC:

- shall transmit in the current valid public uplink window.

- shall set the counter N6 to N7-N8,
- shall randomly generate a new integer N7, larger than or equal to 1 and smaller than or equal to N8,
- shall set V(PUB) to *1*

The public uplink window selection mechanism is completed as soon as an LPDU for that mobile MAC is received.

See figure 14 for the public uplink window selection if N5 is greater than *1*.

NOTE: If N5 is greater than 1, then N8 equals N5

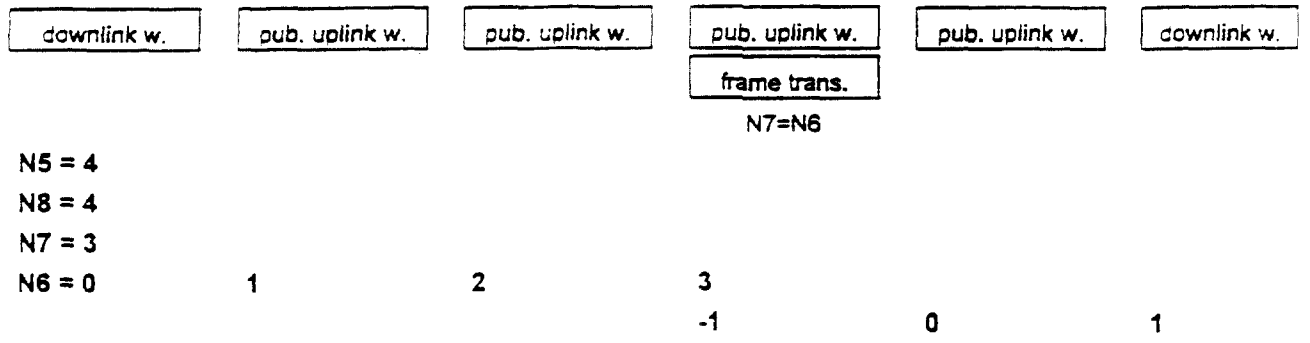


Figure 14: Public Uplink Window Selection when N5 is Greater than 1

If N5 is equal to *1* the mobile MAC shall transmit in the first public uplink window.

It shall then refrain from transmitting in the next N7 - *1* public uplink windows.

See figure 15 for the public uplink window selection when N5 is equal to *1*.

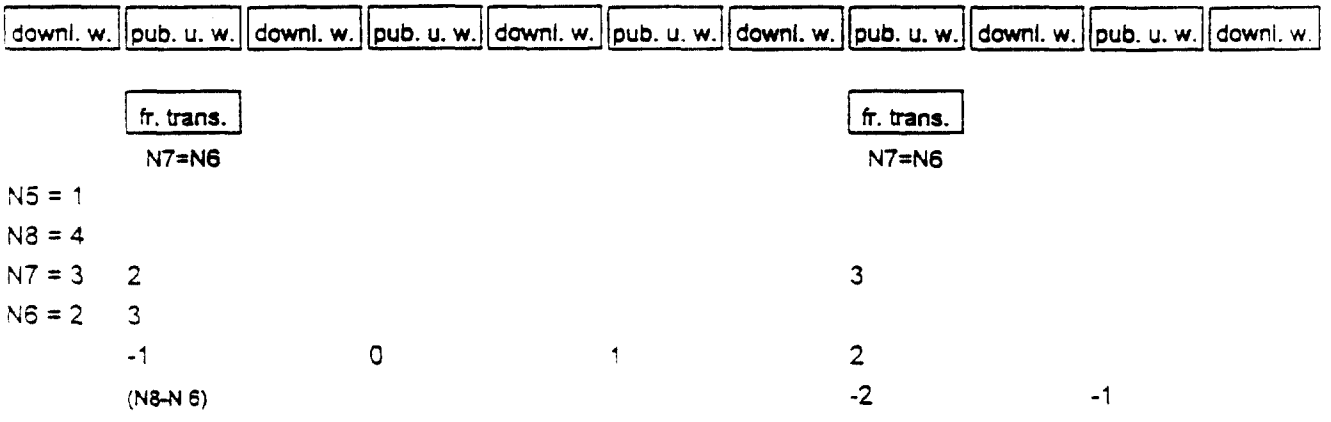


Figure 15: Public Uplink Window Selection when N5 is Equal to *1*

NOTE: Frame transmission (fr. trans.) in figures 14 and 15 encompass layer 2 frame (including zero bit insertion) and pre- an /or postambles if applicable.

6.2 MAC Services and Primitives

The MAC sublayer offers the following primitives to the LLC sublayer:

- MA-DATA.request
- MA-DATA.indication

which are shown in figure 16.

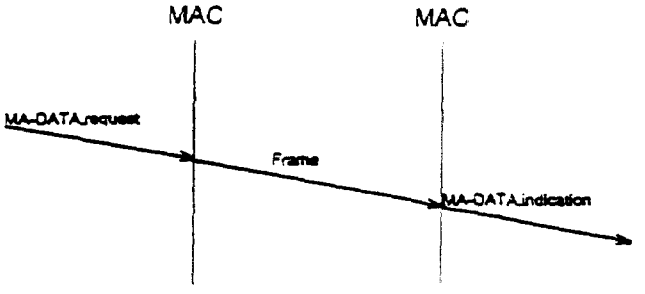


Figure 16: MAC Services And Primitives

The parameters of the primitives are different in the fixed MAC and in the mobile MAC and they are therefore divided into two groups: F-MA-DATA primitives and M-MA-DATA primitives, as described in the following subclauses.

6.2.1 Fixed MAC Sublayer Primitives

6.2.1.1 F-MA-DATA.request

The primitive shall be passed from the LLC sublayer to the MAC sublayer to request that an LPDU is transmitted to a mobile SAP in the first available downlink window.

The primitive shall provide the following parameters

```
F-MA-DATA.request(
                    link address,
                    LPDU,
                    RR
                    )
```

The link address shall be the address of the mobile SAP for which the frame is intended.

It may be a private address of length N1, the broadcast address or a multicast address.

The LPDU may be null (in this case no LPDU shall be included in the frame transmitted).

The response request (RR) shall indicate that the MAC shall allocate an uplink window in immediate connection to the downlink frame transmitted.

6.2.1.2 F-MA-DATA.indication

The primitive shall be passed from the MAC sublayer to the LLC sublayer to indicate the successful reception of a valid frame from a mobile SAP.

The primitive shall provide the following parameters

```
F-MA-DATA.indication(
                    link address,
                    LPDU
                    )
```

The link address shall be the content of the link address field of the frame received.

The LPDU shall not be null.

6.2.2 Mobile MAC Sublayer Primitives

6.2.2.1 M-MA-DATA.request

The primitive shall be passed from the LLC sublayer to the MAC sublayer to request that an LPDU is transmitted to the fixed SAP in an uplink window.

The primitive shall provide the following parameters

```
M-MA-DATA.request(
                    link address,
                    LPDU
                    )
```

The link address shall be the private address of the mobile SAP.

The LPDU may be null (in this case no LPDU shall be included in the frame transmitted).

NOTE: The uplink window may be public or private, see subclause 6.4.2.2.1.

6.2.2.2 M-MA-DATA.indication

The primitive shall be passed from the MAC sublayer to the LLC sublayer to indicate the successful reception of a valid frame from a fixed SAP.

The primitive shall provide the following parameters

```
M-MA-DATA.indication(
                    link address,
                    LPDU
                    )
```

The link address shall be the content of the link address field of the frame received.

The LPDU shall not be null.

6.3 MAC Elements of Procedure

The MAC elements of procedure are represented on the link by the MAC control field which is described in subclause 4.3.

6.3.1 The L bit

The L bit is the LPDU existence bit.

It shall be used to indicate whether the frame contains an LPDU or not. The L bit shall be *1* to indicate the presence of an LPDU and *0* to indicate the absence of an LPDU.

6.3.2 The D bit

The D bit is the direction bit.

It shall be used to indicate the direction of the frame.

The D bit shall be set to *0* in downlink frames and to *1* in uplink frames.

6.3.3 The A bit

The A bit is the medium allocation bit.

The A bit exists only in downlink frames.

It shall be used to indicate the allocation of uplink window succeeding the downlink frame.

The A bit shall be set to *1* to indicate that uplink window is allocated and to *0* to indicate that uplink window is not allocated.

The allocation may be a private uplink window or one or many public uplink windows.

6.3.4 The R bit

The R bit is the medium request bit.

The R bit exists only in uplink frames.

It shall be used to indicate that the mobile MAC requests a private uplink window allocation.

The R bit shall be set to *1* to indicate that private uplink window is requested and to *0* to indicate that private uplink window is not requested.

The request shall lead to the allocation of a private uplink window, see subclause 6.4.2.1.3.

6.3.5 The C/R bit

The C/R bit is under the control of the LLC sublayer

6.3.6 Medium Allocation State Variable V(A)

V(A) is the private medium allocation state variable.

It shall be used to enable the mobile MAC to distinguish between first time allocation of a private uplink window and any possible subsequent reallocations of that window.

When a new SAP is created, V(A) shall be set to 0

6.3.7 The S bit

The S bit is the medium allocation sequence bit. It shall only have meaning in downlink frames.

In the Fixed Equipment it shall be set equal to V(A) of the private SAP corresponding to the mobile MAC to which a private uplink window is allocated.

In the Mobile Equipment it shall be compared to V(A) of the private SAP to determine whether the medium allocation is a reallocation or not.

6.3.8 Private Medium Response Timer

In each mobile MAC there is a private medium response timer.

After a private uplink window request, the corresponding private uplink window allocation and subsequent reallocations by the Fixed Equipment, shall take place before the private medium response timer expires.

The private medium response timer shall be reset each time a private uplink window is requested.

The private medium response timer shall be incremented for each public uplink window allocation.

The maximum value for the timer is N12.

6.4 MAC Procedures

6.4.1 Fixed Equipment MAC Procedures

6.4.1.1 Frame Reception

6.4.1.1.1 Validity of frame

The MAC sublayer shall inspect all received frames to assess their validity.

A received frame shall be considered valid if

a) the frame is correctly delimited by start and end flags according to subclause 4.1 and

b) the frame (after deletion of zero bits inserted for transparency) contains a number of bits equal to 8xN (with N being an integer number)

c) the frame contains a valid address field according to subclause 4.2 indicating the private address of an SAP and

d) the frame contains a MAC control field according to subclause 4.3 and

e) the frame does not consist of too many octets (parameters N3 and N4 respectively) and

f) the frame contains a valid FCS field according to subclause 4.5.

If the frame received is not valid it shall be discarded. If a non valid frame was received in a private uplink window, reallocation may be undertaken according to subclause 6.4.1.2.3.

6.4.1.1.2 Information transfer

If the L bit of a received valid frame is set to *1* this shall indicate that the frame contains an LPDU. The start and end flags, the FCS, the link address field and the MAC control field shall be removed from the frame. The LPDU and the contents of the link address field shall then be passed to the LLC sublayer in an F-MA-DATA.indication.

6.4.1.1.3 Private uplink window request

If the R bit of a received valid frame is set to *1* this shall indicate that the remote mobile SAP indicated by the link address field is requesting a private uplink window to be allocated to it. The fixed MAC should allocate a private uplink window to that SAP before the private medium response timer (see subclause 6.3.8) has expired.

6.4.1.2 Frame transmission

6.4.1.2.1 Information transfer

As a result of an *F*-MA-DATA.request an LPDU may be pending.

The fixed MAC shall then construct a frame according to the frame format of clause 4.

The L bit of the MAC control field shall be set to *1* and the D bit to *0*.

The A bit and the S bit shall be set according to subclauses 6.4.1.2.2. and 6.4.1.2.3.

The frame shall then be passed to the lower layer

6.4.1.2.2 Private uplink window allocation

The fixed MAC shall allocate a private uplink window to a remote mobile SAP if an outgoing LPDU contains a command to that SAP, requiring an immediate response.

The fixed MAC may allocate a private uplink window to a remote mobile SAP if a private uplink window has been requested from (but not yet granted to) that SAP.

The fixed MAC may allocate a private uplink window to a remote mobile SAP if a private uplink window previously allocated to that SAP contained no valid uplink frame (reallocation).

When a private uplink window is allocated the A bit of the allocating frame shall be set to *1*. The link address field of the allocating frame shall contain the private link address of a remote SAP to which the private uplink window is allocated.

The S bit shall be set equal to the value of V(A).

If a private uplink window allocation to a mobile MAC is either the first response to a private uplink window request from that mobile MAC, or the result of an *F*-MA-DATA.request the value of the corresponding V(A) shall be complemented after the allocating frame is constructed.

6.4.1.2.3 Private uplink window reallocation

Each time a private uplink window is allocated by the fixed MAC, a transmission from the mobile MAC, to which the window is allocated, is expected.

If no valid frame was received by the fixed MAC it may reallocate the private uplink window as long as the corresponding private medium response timer has not expired.

The S bit of the MAC control field shall then have the same value as the first time that window was allocated. The value of V(A) for that SAP shall not be complemented.

6.4.1.2.4 Public uplink window allocation

When public uplink windows are allocated the A bit of the allocating frame shall be set to *1*. The link address field of the allocating frame shall contain the broadcast address. The number of consecutive public uplink windows simultaneously allocated shall be N5.

6.4.2 Mobile Equipment MAC Procedures

6.4.2.1 Frame Reception

6.4.2.1.1 Validity of Frame

The MAC sublayer shall inspect all received frames to assess their validity.

A received frame shall be considered valid if:

a) the frame is correctly delimited by start and end flags according to subclause 4.1 and

b) the frame contains a valid address field according to subclause 4.2 , indicating either the link address of the private SAP of this Mobile Equipment or the broadcast address or a multicast address known by this Mobile Equipment and

c) the frame contains an MAC control field according to subclause 4.3 and

d) the frame does not consist of too many octets (parameter N2) and

e) the frame contains a valid FCS field according to subclause 4.5.

If the frame received is not valid it shall be discarded

6.4.2.1.2 Information Transfer

If the L bit of a received valid frame is set to *1* this shall indicate that the frame contains an LPDU. The start and end flags, the FCS, the link address field and the MAC control field shall be removed from the frame. The LPDU and the contents of the link address field shall then be passed to the LLC sublayer in an M-MA-DATA.indication.

6.4.2.1.3 Private Uplink Window Allocation

If the A bit of the received frame equals *1* and the link address is private, a private uplink window is allocated by the received frame.

If the medium allocation state variable V(A) of the received frame equals *1*, indicating that an LPDU is present, the state variable V(A) shall be set to the value of the S bit of the received frame.

If the medium allocation state variable V(A) of the received frame equals *0*, indicating that no LPDU is present, the value of the S bit shall be compared to the current value of V(A).

If they are unequal, the allocation is not a reallocation, and the private uplink window shall be used for transmitting a pending LPDU.

If they are equal the allocation is a reallocation and the MAC shall use the private uplink window for retransmitting the frame transmitted in the previous private uplink window.

6.4.2.1.4 Public Uplink Window Allocation

If the A bit of the received frame equals *1* and the link address is the broadcast address public uplink window is allocated by the received frame. The number of simultaneously allocated consecutive public uplink windows is indicated by parameter N5.

The ~~mobile~~ MAC may transmit in the public uplink window selected, see subclause 6.1.2.3.

6.4.2.2 Frame Transmission

6.4.2.2.1 Information Transfer

As a result of an M-MA-DATA.request an LPDU may be pending.

The mobile MAC shall then construct a frame according to the frame format of clause 4.

The L bit and the D bit of the MAC control field shall be set to *1*.

The R bit shall be set according to subclause 6.4.2.2.2.

The mobile MAC shall then transmit the frame according to the following rules:

a) If the LPDU contains an LLC command and if a public uplink window is allocated first, and if the frame fits into the size of public uplink windows, as indicated by parameter N4, the mobile MAC shall transmit the frame in the public uplink window selected by the selection mechanism, see subclause 6.1.2.3.

b) If the LPDU contains an LLC command and if a public uplink window is allocated first, and if the frame does not fit into the size of public uplink windows, as indicated by parameter N4, the mobile MAC shall transmit a request for private uplink window, see subclause 6.4.2.2.2, in the public uplink window selected by the selection mechanism, see subclause 6.1.2.3.

c) If the LPDU contains an LLC command and if a private uplink window is allocated first, the mobile MAC shall transmit the frame in the private uplink window.

d) If the LPDU contains an LLC response the mobile MAC shall transmit the frame in the first private uplink window allocated.

If the frame is transmitted in a private uplink window it shall be kept pending at least until the private medium response timer has expired.

6.4.2.2.2 Private Uplink Window Request

The mobile MAC can request that a private uplink window be allocated to it by the fixed MAC.

There are three cases:

a) If the mobile MAC has a command frame to transmit that does not fit into a public uplink window and has not requested a private uplink window for that frame, it shall request a private uplink window by transmitting a frame with the L bit of the MAC control field set to *0* and the R bit set to *1*.

b) If the mobile MAC has a frame to transmit that does not fit into a public uplink window and has already requested a private uplink window for that frame it shall retransmit the request after the private medium response timer has expired.

c) If the mobile MAC has a frame to transmit in a private or public uplink window and still has an LPDU pending it shall request (another) private uplink window by setting the R bit of the MAC control field of the transmitted frame to *1*.

7. LOGICAL LINK CONTROL (LLC) SUBLAYER (Normative)

The LLC generates command PDUs and response PDUs for transmission and interprets received command PDUs and response PDUs. Specific responsibilities assigned to an LLC include

a) Initiation of control signal interchange,

b) Organisation of data flow,

c) Interpretation of received command PDUs and generation of appropriate response PDUs, and

d) Actions regarding error control and error recovery functions in the LLC sublayer.

The LLC sublayer provides a description of the peer-to-peer protocol procedures that are defined for the transfer of information and control between any pair of data link layer service access points in a DSRC communication environment.

To satisfy a broad range of potential applications two types of data link control operation are included (see subclause 7.3).

The first type (referred to as Type 1) of operation provides an unacknowledged connectionless-mode service across a data link with minimum protocol complexity. This type of operation may be useful when higher layers provide any essential recovery and sequencing services so that these do not need replicating in the data link layer. In addition, this type of operation may prove useful in applications where it is not essential to guarantee the delivery of every data link layer data unit and for some initial data transfer.

The second type (referred to as Type 3) of operation provides an acknowledged connectionless-mode data unit exchange service, which permits a station to both transmit data and request the return of data at the same time. Although the exchange service is connectionless, in-sequence delivery is guaranteed for data transmitted by the initiating station.

NOTE 1: The definition of this LLC sublayer is based on the ISO 8802-2 : 1989; Information processing systems - Local area networks - Part 2: Logical link control .
That International Standard defines three types of operation:
- *Type 1: Unacknowledged Connectionless-Mode Services*
- *Type 2: Connection-Mode Services*
- *Type 3: Acknowledged Connectionless-Mode Services*

Type 2 is not adopted, because of the overhead for connection establishing and disconnection which is not suitable for the real-time environment of DSRC.

NOTE 2: Unlike the MAC sublayer there is no master / slave structure in the LLC. That can be achieved by defining master / slave communication profiles.

7.1 LLC Sublayer Service Specifications

This subclause covers the services required of, or by, the LLC sublayer at the logical interfaces with the LLC user.

This subclause specifies the services required of the LLC sublayer by the DSRC LLC sublayer user, as viewed from the LLC sublayer user, to allow an LLC sublayer user entity to exchange packets with remote peer LLC sublayer user entities. The services are described in an abstract way and do not imply any particular implementation or any exposed interface.

Two forms of service are provided

a) unacknowledged connectionless-mode

b) acknowledged connectionless-mode:

Unacknowledged Connectionless-Mode Service. The data transfer service that provides the means by which data link user entities can exchange link service data units (LSDUs) without the establishment of a data link level connection on an unacknowledged base. The data transfer can be point-to-point, multicast, or broadcast.

Acknowledged Connectionless-Mode Services. The acknowledged connectionless-mode data unit exchange services provide the means by which data link user entities can exchange link service data units (LSDUs) which are acknowledged at the LLC sublayer, without the establishment of a data link connection. The services provide a means by which a data link user

entity at one station can transmit a data unit to another station, request a previously prepared data unit from another station, or exchange data units with another station. The data unit transfer is point-to-point.

7.1.1 Overview of Interactions

The primitives associated with unacknowledged connectionless-mode data transfer are:

DL-UNITDATA.request
DL-UNITDATA.indication

The DL-UNITDATA.request primitive is passed to the LLC sublayer to request that an LSDU be transmitted using unacknowledged connectionless-mode procedures. The DL-UNITDATA.indication primitive is passed from the LLC sublayer to indicate the arrival of an LSDU.

The primitives associated with the acknowledged connectionless-mode data unit transmission service are:

DL-DATA-ACK.request
DL-DATA-ACK.indication
DL-DATA-ACK-STATUS.indication

The DL-DATA-ACK.request primitive is passed to the LLC sublayer to request that an LSDU be transmitted to a remote LLC using acknowledged connectionless-mode data unit transmission procedures. The DL-DATA-ACK.indication primitive is passed from the LLC sublayer to indicate the arrival of a command PDU except in the case where this PDU is used only for resynchronisation. The DL-DATA-ACK-STATUS.indication primitive is passed from the LLC sublayer to convey the results of the previous associated DL-DATA-ACK.request primitive.

The primitives associated with the acknowledged connectionless-mode data unit exchange service are:

DL-REPLY.request
DL-REPLY.indication
DL-REPLY-STATUS.indication

The DL-REPLY.request primitive is passed to the LLC sublayer to request that an LSDU be returned from a remote station or that LSDUs be exchanged between stations using acknowledged connectionless-mode data unit exchange procedures. The DL-REPLY.indication primitive is passed from the LLC sublayer to indicate the arrival of a command PDU. The DL-REPLY-STATUS.indication primitive is passed from the LLC sublayer to convey the results of the previous associated DL-REPLY.request primitive.

The primitives associated with reply data unit preparation are:

DL-REPLY-UPDATE request
DL-REPLY-UPDATE-STATUS.indication

The DL-REPLY-UPDATE request primitive is passed to the LLC sublayer with an LSDU to be held by LLC and transmitted at a later time when requested to do so by some other station. The DL-REPLY-UPDATE-STATUS.indication primitive is passed from the LLC sublayer to convey the results of the previous associated DL-REPLY-UPDATE request primitive.

7.1.2 Detailed Service Specifications

This subclause describes in detail the primitives and parameters associated with the identified services. The parameters (except „link address") are defined in an abstract sense. The parameters specify the information that must be available to the receiving entity. A specific implementation is not constrained in the method of making this information available.

The **link address** parameter identifies the local SAP and the remote SAP of both the MAC and the LLC. The „link address" parameter shall have the format as defined in subclause 4.2.

The **data** parameter may be provided by actually passing the link service data unit, by passing a pointer or means. The data parameter may be null.

The **response request** is used by the Fixed Equipment data link layer user to indicate to the data link layer that a response to that LSDU is requested by the data link user (this implies medium allocation at the MAC sublayer).

The **status** parameter indicates the success or failure of a previous associated request.

NOTE 1: Different from the ISO 8802-2 : 1989 MAC and LLC shall have one common address.

NOTE 2: Different from the ISO 8802-2 : 1989 the MAC sublayer is not able to handle priorities. Therefore the „priority" parameter is not specified.

Possible logical sequences of successful data unit transmission are illustrated in figures 18 a-e. Primitive types that occur earlier in time and are connected by dotted lines in the diagrams are the logical antecedents of subsequent primitive types.

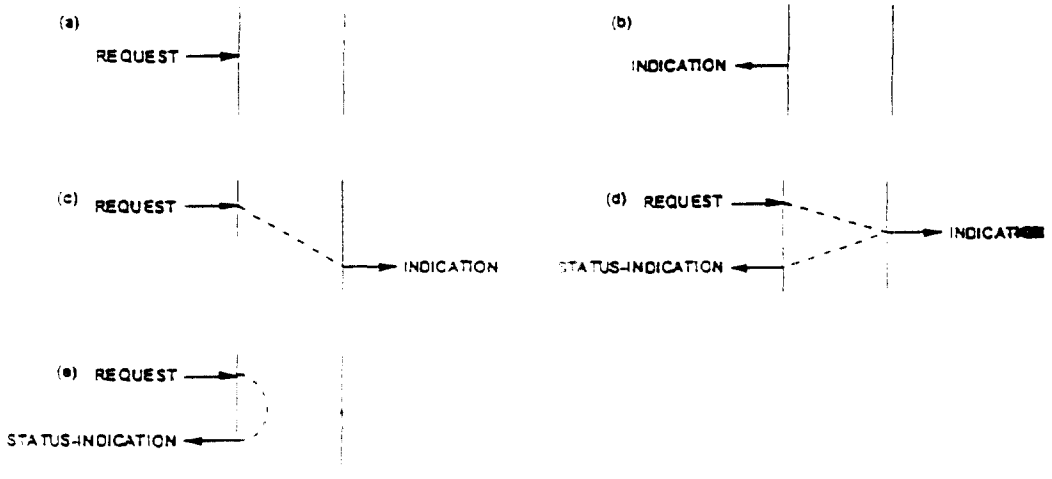


Figure 18: Time-Sequence Diagram

7.1.2.1 DL-UNITDATA.request

This primitive is the service request primitive for the unacknowledged connectionless-mode data transfer service.

DL-UNITDATA.request of the Mobile Equipment

The primitive in the Mobile Equipment shall provide parameters as follows:

DL-UNITDATA.request(
link address,
data
)

The link address shall specify a private link address.

This primitive is passed from the data link user to the LLC sublayer to request that an LSDU be transmitted to the remote (fixed) SAP using unacknowledged connectionless-mode procedures.

DL-UNITDATA.request of the Fixed Equipment

The primitive in the Fixed Equipment shall provide parameters as follows:

DL-UNITDATA.request(
link address,
data,
response request
)

The link address shall specify either a private, multicast or broadcast. The response request parameter shall be used to enable a direct response from the mobile data link layer user. The response request parameter shall be passed directly to the MAC sublayer.

This primitive is passed from the data link user to the LLC sublayer to request that an LSDU be transmitted to one or more (mobile) SAP(s) using unacknowledged connectionless-mode procedures.

NOTE: The response request parameter enables the data link user to request the allocation of uplink windows.

7.1.2.2 DL-UNITDATA.indication

This primitive is the service indication primitive for the unacknowledged connectionless-mode data unit transfer service.

The primitive shall provide parameters as follows

DL-UNITDATA.indication(
link address,
data
)

At the Fixed Equipment the link address shall be a private address.

At the Mobile Equipment the link address shall be a private, multicast or broadcast address.

This primitive is passed from the LLC sublayer to the data link user to indicate the arrival of an LSDU from the specified remote entity.

7.1.2.3 DL-DATA-ACK.request

This primitive is the service request primitive for the acknowledged connectionless-mode data unit transmission service.

The primitive shall provide parameters as follows:

DL-DATA-ACK.request(
link address,
data
)

The link address shall specify a private link address.

This primitive is passed from the data link user to the LLC sublayer to requests that an LSDU be transmitted to a remote SAP using acknowledged connectionless data unit transmission procedures.

7.1.2.4 DL-DATA-ACK.indication

This primitive is the service indication primitive for the acknowledged connectionless-mode data unit transmission service.

The primitive shall provide parameters as follows:

DL-DATA-ACK.indication(
link address,
data
)

The link address shall specify a private link address.

This primitive is passed from the LLC sublayer to the data link user to indicate the arrival of a non-null, non-duplicate LSDU from a remote data link user entity.

7.1.2.5 DL-DATA-ACK-STATUS.indication

This primitive is the service status indication primitive for the acknowledged connectionless-mode data unit transmission service.

The primitive shall provide parameters as follows:

DL-DATA-ACK-STATUS.indication(
link address,
status
)

The link address shall specify a private link address. The „status" parameter indicates the success or failure of the previous associated acknowledged connectionless-mode data unit transmission request.

This primitive is passed from the LLC sublayer to the data link user to indicate the success or failure of the previous associated acknowledged connectionless-mode data unit transmission request.

7.1.2.6 DL-REPLY.request

This primitive is the service request primitive for the acknowledged connectionless-mode data unit exchange service. This primitive can be used to request a previously prepared data unit from another station, or to exchange data units with another station.

The primitive shall provide parameters as follows:

DL-REPLY.request(
link address,
data
)

The link address shall specify a private link address

This primitive is passed from the data link user to the LLC sublayer to request a previously prepared data unit from another SAP, or to exchange data units with another SAP using acknowledged connectionless-mode data unit exchange procedures.

NOTE: This primitive can be passed with a null (having zero length) data parameter for the purpose of requesting data only (without transmitting data).

7.1.2.7 DL-REPLY.indication

This primitive is the service indication primitive for the acknowledged connectionless-mode data unit exchange service.

The primitive shall provide parameters as follows

DL-REPLY.indication(
link address,
data
)

The link address shall specify a private link address.

This primitive is passed from the LLC sublayer to the data link user to indicate either a successful request of an LSDU from the remote data link user entity, or exchange of LSDUs with a remote data link user entity.

The transfer of a previously prepared LSDU to a requesting station shall not destroy the original copy of the LSDU. Subsequent requests for data by any station shall cause the transfer of the same LSDU, until the DL-REPLY-UPDATE.request primitive is used to replace the LSDU with new information.

7.1.2.8 DL-REPLY-STATUS.indication

This primitive is the service status indication primitive for the acknowledged connectionless-mode data unit exchange service.

The primitive shall provide parameters as follows:

DL-REPLY-STATUS.indication(
link address,
data,
status
)

The link address shall specify a private link address. The status parameter indicates the success or failure of the previous acknowledged connectionless mode data exchange request.

This primitive is passed from the LLC sublayer to the data link user to indicate the success or failure of the previous associated acknowledged connectionless-mode data unit exchange request and to pass data if available.

7.1.2.9 DL-REPLY-UPDATE.request

This primitive is the service request primitive for the reply data unit preparation service.

The primitive shall provide parameters as follows:

DL-REPLY-UPDATE.request(
link address,
data
)

The link address shall specify a private link address. The data parameter specifies the link service data unit to be held by LLC, in preparation for transfer at a later time when requested.

This primitive is passed from the data link user to the LLC sublayer to request that an LSDU be associated with a local SAP and held by LLC for future access.

Once an LSDU has been associated with a local SAP, that LSDU shall be transferred to other stations using the acknowledged connectionless-mode response PDU as often as requested by other stations (without the need for additional DL-REPLY-UPDATE.request primitives from the data link user). A subsequent DL-REPLY-UPDATE.request primitive from the data link user for the specified SAP serves to replace the currently associated LSDU with a new LSDU.

7.1.2.10 DL-REPLY-UPDATE-STATUS.indication

This primitive is the service confirmation primitive for the reply data unit preparation service.

The primitive shall provide parameters as follows:

```
DL-REPLY-UPDATE-STATUS.indication(
                    link address,
                    status
                    )
```

The link address shall specify a private link address. The status parameter indicates the success or failure of the previous associated reply data unit preparation request.

This primitive is passed from the LLC sublayer to the data link user to indicate the success or failure of the previous associated data unit preparation request.

The effect of receipt of this primitive by the data link user is unspecified.

If the status is successful, this primitive indicates that the LLC sublayer has associated the LSDU with the local SAP.

7.2 LPDU Structure

This subclause defines in detail the LPDU structure. It defines the relative positions of the various components of the PDU.

7.2.1 LPDU Format

All LPDUs shall conform to the format shown in figure 19.

Control	Information
8 bits	N × 8 bits

Control = Control field (see subclause 7.4)

N = Number of octets; an integer value equal to or greater than *0* (upper bound of N is a parameter of the MAC)

Figure 19: LPDU Format

7.2.2 Elements of the LPDU

7.2.2.1 Address Field

The link address is used for the MAC sublayer and the LLC sublayer and is therefore not contained in the LPDU.

The link address on the downlink shall identify the one (private) or more (multicast, broadcast) SAP(s) for which the LLC information field is intended and the SAP from which the data transfer was initiated. The link address on the uplink shall identify the specific (private) SAP for which the LLC information field is intended and the SAP from which the LLC information field was initiated.

The format of the link address field shall be as defined in subclause 4.2.

The link address shall be created as described in clause 5.

7.2.2.2 Command/Response Bit

The Command/Response Bit shall be located as bit 4 in the MAC control field (see subclause 4.3). If this bit is *0*, it shall indicate that the LPDU is a command. If this bit is *1*, it shall indicate that the LPDU is a response.

NOTE: In ISO 8802-2 : 1989 The Command/Response Bit is located in the least significant bit of the SSAP address field.

7.2.2.3 LLC Control Field

The LLC control field shall consist of one octet that shall be used to designate command and response. The content of this field shall be as described in subclause 7.4.

7.2.2.4 Information Field

The information field shall consist of any integral number (including zero) of octets.

7.2.2.5 Bit Order

Commands and Responses shall be delivered to / received from the MAC sublayer least significant bit first (i.e., the first bit of an octet that is delivered / received shall have the weight 2^0). The information field shall be delivered to the MAC sublayer in the same bit order as received from the data link layer user. The information field shall be delivered to the data link layer user in the same bit order as received from the MAC sublayer.

7.2.2.6 Invalid LPDU

An invalid LPDU shall be defined as one which meets at least one of the following conditions:

a) It is identified as such by the MAC sublayer.

b) It is not an integral number of octets in length.

c) Its length is *0* (no control field).

d) It does not contain a valid command or response control field as defined by this standard.

e) It does contain a Type 3 LLC command or response control field, and the link address is multi- or broadcast.

f) It does contain a Type 3 response control field and no ACn response status subfield in its information field.

Invalid LPDUs shall be ignored.

7.3 LLC Types of Procedure

LLC defines two types of operation for data communication between service access points.

Type 1 Operation. With Type 1 operation, PDUs shall be exchanged between LLCs without the need for the establishment of a data link connection. In the LLC sublayer these PDUs shall not be acknowledged, nor shall there be any flow control or error recovery in the Type 1 procedures.

NOTE: Type 1 Operation is typically used for information which is multi- or broadcasted, in the negotiation phase, or where acknowledgement facilities of the upper layers are used.

Type 3 Operation. With Type 3 operation, PDUs shall be exchanged between LLC entities without the need for the establishment of a data link connection. In the LLC sublayer, PDUs which may or may not bear information shall be acknowledged. The acknowledgement function shall be accomplished by the destination LLC returning to the source LLC a specific response in a separate PDU which contains status information and may or may not bear user information.

In normal operation, each command PDU in Type 3 operation shall receive an acknowledgement PDU, and though the source LLC may retransmit a Type 3 command PDU for recovery purposes, it shall not transmit a new Type 3 command PDU while waiting for an acknowledgement of a previous PDU with the same link address. The LLC entity shall not accept a new request primitive from the data link user until the receipt of the preceding "request" primitive LSDU has been acknowledged by the remote LLC entity. This restriction is necessary to allow higher layers to perform recovery operations before resuming normal data transmission in case LLC is unsuccessful in transmitting a PDU (after retries).

A mechanism of alternating LLC control field code in successive PDUs provides an one-bit sequence number functionality which allows the LLC receiving a command PDU to differentiate between a new PDU and a second copy of a previously received PDU. Further, the LLC receiving an acknowledgement PDU can insure that the acknowledgement refers to the last transmitted information PDU. A previously received acknowledgement which incurred excessive delay is thus ignored.

The Type 3 operation defines state information which must be maintained at the stations involved in the information exchange. Each station shall maintain for each SAP, a one-bit sequence number for transmitting and another for receiving. Therefore a Mobile Equipment has to maintain one pair of send / receive sequence numbers, if using Type 3 operation. A Fixed Equipment has to

maintain, for each Mobile Equipment using Type 3 operation in the communication zone, one pair of send / receive sequence numbers.

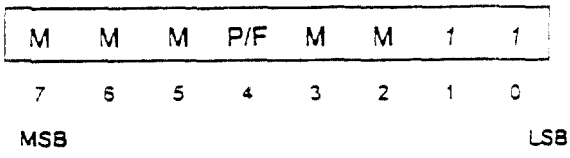
Type 3 operation shall only be used in a point-to-point (private) communication.

7.4 LLC Elements of Procedure

This subclause specifies the elements of the DSRC LLC procedures for code-independent data communication using the LPDU structure (see subclause 7.2).

7.4.1 Control Field Format

The format defined for the control field is described in figure 20.



M Modifier function bits

P/F Poll bit - command LPDU transmission
Final bit - response LPDU transmission
(*1* = Poll/Final)

The two least significant bits are set to *1*

Figure 20: LPDU Control Field

The PDUs shall be used to provide data link control functions and information transfer. The PDUs shall include a P/F bit that shall be set according to subclause 7.5.2.

NOTE: The control field shown in figure 20 utilises a subset of the 8802-2 : 1989 LLC control field format.

7.4.2 Control Field Parameters

7.4.2.1 Type 3 Operation Parameters

Transmit Sequence State Variable V(SI). The LLC shall be able to maintain one transmit sequence state variable V(SI) for each unique SAP used for transmitting Type 3 command PDUs. These variables shall only take on the values of *0* and *1* and shall be set equal to bit eight of the LLC control field code used for the last Type 3 response PDU received with the link address. The V(SI) variables permit the LLC to insure that a received acknowledgement applies to the currently outstanding transmission and allows the receiver to detect duplicate frames. V(SI) shall be created with the establishment of a new private link address

Receive Sequence State Variable V(RI). The LLC shall be able to maintain one receive sequence state variable V(RI) for each unique SAP associated with received Type 3 command PDUs. This variable contains the complement of bit eight of the AC0 or AC1 LLC control field code of the last received Type 3 command with the associated link address. V(RI) allows the LLC to differentiate between a Type 3 command PDU received for the first time, and a received PDU which is a retransmission of a previously received PDU. V(RI) shall be created with the establishment of a new private link address.

Reception Status State Variable V(RB). The LLC shall be able to maintain one reception status state variable V(RB) for each SAP associated with received Type 3 command PDUs. This variable contains an indication of the success or failure of the reception of the information field from the last received Type 3 command with the associated link address. V(RB) insures that the response to a duplicate command PDU contains the same reception status code as the response to the original command PDU. The reception status state variable V(RB) shall be changed if the last reception was successfull, but previous not.

7.4.3 Commands and Responses

This subclause defines the commands and associated responses. Subclauses 7.4.3.1 and 7.4.3.2 contain the definitions of the set of commands and responses (listed below) for each of the control field formats for Type 1 and Type 3 operation, respectively. The C/R bit, located in bit four of the MAC control field, is used to distinguish between commands and responses. Table 1 shows the commands and responses.

Table 1: Commands and Responses of Type 1 and Type 3 Operation

Commands	Responses
UI - Unnumbered Information	
AC0 - Acknowledged Connectionless Information, Seq. 0	AC0 - Acknowledged Connectionless Acknowledge, Seq. 0
AC1 - Acknowledged Connectionless Information, Seq. 1	AC1 - Acknowledged Connectionless Acknowledge, Seq. 1

7.4.3.1 Type 1 Operation Commands

The PDU command LLC control field encoding for Type 1 operation is shown in figure 21.

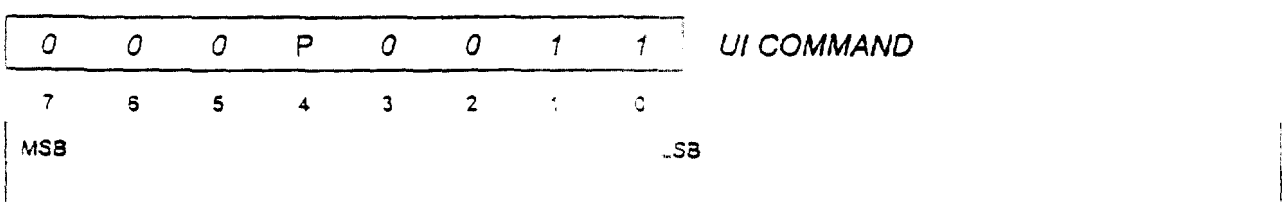


Figure 21: Type 1 Operation Command. Control Field Bit Assignment

Unnumbered Information (UI) Command. On the downlink, the UI command PDU shall be used to transmit information to one or more mobile SAP(s) (private, multicast or broadcast link

address).On the uplink, the UI command PDU shall be used to transmit information to one fixed SAP (private link address).

The use of the UI command PDU is not dependent on the existence of a data link connection between the destination and source LLCs, and its use will not affect the V(SI) or V(RI) variables of the Type 3 Operation. There is no LLC response PDU to the UI command PDU.

The data contained in an UI PDU may be lost if a logical data link exception occurs during the transmitting of the command PDU.

7.4.3.2 Type 3 Operation Commands and Responses

The Type 3 command and response PDU LLC control field encoding is listed in figure 22:

0	*1*	*1*	P	*0*	*1*	*1*	*1*	AC0 COMMAND
1	*1*	*1*	P	*0*	*1*	*1*	*1*	AC1 COMMAND
0	*1*	*1*	F	*0*	*1*	*1*	*1*	AC0 RESPONSE
1	*1*	*1*	F	*0*	*1*	*1*	*1*	AC1 RESPONSE
7	6	5	4	3	2	1	0	
MSB							LSB	

Figure 22: Type 3 Operation Command and Response, Control Field Bit Assignment

Acknowledged Connectionless Information (ACn) Command. In Type 3 operation the ACn command PDU shall be used to transmit information or to request information, without the prior establishment of a data link connection. Use of the ACn command PDU is not dependent upon the existence of a data link connection between the destination and source. Reception of an ACn command PDU shall be acknowledged by an ACn response PDU at the earliest opportunity. The ACn command shall have a private link address. The information field in the ACn command PDU may be either null (having zero length) or non-null, and if non-null, shall contain a link service data unit.

NOTE: The use of the ACn command with a multi or broadcast address is not allowed.

Acknowledged Connectionless Acknowledgement (ACn) Response. In Type 3 operation the ACn response PDU shall be used to reply to an ACn command PDU. Responses shall be made at the earliest opportunity, The ACn response PDU shall identify the responding LLC and be transmitted to the originating LLC. The ACn response PDU shall always contain a status subfield in its information field (see subclause 7.4.3.3).

Table 2 summarises the functions performed by ACn command and response PDUs according to the state of the P/F bit and the presence of a non-null LSDU.